R-93

FACILITY FORM 602

N64 28876	
(ACCESSION NUMBER)	(THRU)
13	1
(PAGES)	(CODE)
NASA CR-58675	16
(NASA CR OR TMX OR AD NUMBER)	(CATEGORY)

THE EFFECTS OF CORIOLIS ACCELERATION DURING ZERO GRAVITY FLIGHT ON CERTAIN HEMATOLOGICAL AND URINARY PARAMETERS IN NORMAL AND LABYRINTHINE DEFECTIVE SUBJECTS

JOINT REPORT

UNITED STATES NAVAL SCHOOL OF AVIATION MEDICINE

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

OTS PRICE

XEROX $ 1.60 ph

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REPORTS CONTROL NO. 7

Research Report

THE EFFECTS OF CORIOLIS ACCELERATION DURING ZERO GRAVITY FLIGHT ON CERTAIN HEMATOLOGICAL AND URINARY PARAMETERS IN NORMAL AND LABYRINTHINE DEFECTIVE SUBJECTS*

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Bureau of Medicine and Surgery
Project MR005.13-0004
Subtask 2 Report No. 2

NASA Order No. R-93

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19 May 1964

*This research was conducted under the sponsorship of the Office of Life Science Programs, National Aeronautics and Space Administration.

U. S. NAVAL SCHOOL OF AVIATION MEDICINE
U. S. NAVAL AVIATION MEDICAL CENTER
PENSACOLA, FLORIDA

SUMMARY PAGE

THE PROBLEM

To measure blood and urinary changes in normal and labyrinthine defective subjects after repetitive, zero-G, parabolic flight with and without the cumulative effects of Coriolis acceleration.

FINDINGS

ABST

Twenty-one normal and four labyrinthine defective (L-D) subjects were exposed to repetitive, twenty-second intervals of zero gravity or zero gravity plus Coriolis acceleration in parabolic flight. The normal subjects showed significant hematological and biochemical evidence of stress in the form of leukocytic changes and alteration in excretion rates of corticosteroids, while the L-D group were virtually free of such changes. Catechol amine excretions were not significantly altered in either group nor were the muscle metabolism parameters, lactic and pyruvic acids and lactic acid dehydrogenase.

The results of the experiment suggest that functional vestibular organs are necessary for the transmission of stress stimuli through the hypothalmic-pituitary-adrenal axis in short-cycle zero-G environment especially when Coriolis acceleration is present.

Author

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ACKNOWLEDGMENT

The author would like to express his appreciation to the participants in the experiment for the opportunity of collecting the many specimens necessary to conduct this study. He is also indebted to Mrs. Dolores Beaver for much of the analytical work of the experiment.

INTRODUCTION

Although biochemical and hematological changes during sustained zero gravity ballistic flight have been well-documented(17,18), little information is available on the response of labyrinthine-defective (L-D) subjects as compared to normals when subjected to repeated, short-cycle, zero-G parabolic flight with and without the added stimulation of Coriolis acceleration. While the latter is not easily tolerated by normal individuals (8) and may be an incidental problem for the occupants of the space platform (8), animals that have undergone bilateral labyrinthectomy have been asymptomatic under such bizarre accelerative conditions (13). Normal and L-D subjects have been shown to have different excretory patterns for epinephrine, norepinephrine, and 17-hydroxycorticosteroids when subjected to the unusual G forces of acrobatic flight (3), presumably from the stimulation of the hypothalmic-pituitary-adrenal axis. It has also not been determined whether a series of parabolic flight maneuvers, with the accompanying load changes imposed on the supportive and functional muscle tissue of the body, would have measurable effects on the glycolytic mechanism parameters such as lactic and pyruvic acids and lactic dehydrogenase. It was the purpose of this experiment to measure the above values in addition to the leukocytic formed elements of the blood in the described zero-G state with and without the added stress of Coriolis acceleration.

PROCEDURE

The zero gravity condition of this experiment was produced in a series of flight parabolas in the KC-135 aircraft expertly carried out by the flight group at Wright-Patterson Air Force Base, Ohio. One mission was flown on each of twelve days, and each mission consisted of an average of twenty-four parabolas with subjects in a zero gravity state for twenty seconds during each parabola. The mean time spent at zero-G on each mission was seven minutes. The test conditions were: 1) zero gravity as described above and 2) zero gravity during which the added stress of Coriolis acceleration was superimposed by means of the Bárány chair. Each group tested was exposed to only one experimental condition per day. The detailed description of the complete zero-G experiment, of which this is only a part, is given elsewhere (9).

Twenty-one normal and four deaf subjects, the latter with associated post-meningitis bilateral labyrinthine defects, were tested. None was habituated to zero gravity but some had extensive flight time as pilots. The normals were either members of the Armed Forces or civilian employees working in various capacities on the project. The L-D personnel were from Gallaudet College and had previously acted as subjects on the various disorientation devices at the Naval School of Aviation Medicine, Pensacola. With the exception of loss of otolith and semicircular canal function in the L-D subjects, both groups were healthy by the usual standards.

Blood samples were collected before takeoff and at the end of each mission four hours later. Leukocyte, lymphocyte, eosinophil, and differential counts were made by conventional methods. Lactic and pyruvic acids were assayed from immediately prepared perchloric acid filtrates using Calbiochem kits No. 8851 and No. 8852, respectively. Lactic dehydrogenase determinations were done on promptly separated serum by the method of Wroblewski and LaDue (22). Blood values determined immediately postflight were compared to the preflight values with each individual serving as his own control.

Urinary values were determined on samples collected for six hours postflight and compared to similar collections on a day during which only normal ambulatory activity was permitted. Previous experience had indicated (3) that this type of reference point is more consistent than a sample collected earlier in the same day because of the considerable change due to diurnal variation. The urine specimins were assayed for epinephrine and norephinephrine by the method of Crout (4) and total 17-hydroxycorticosteroids by the method of Kornel (15). The excretion rates of these hormones were expressed as mean micrograms per hour over a six-hour period.

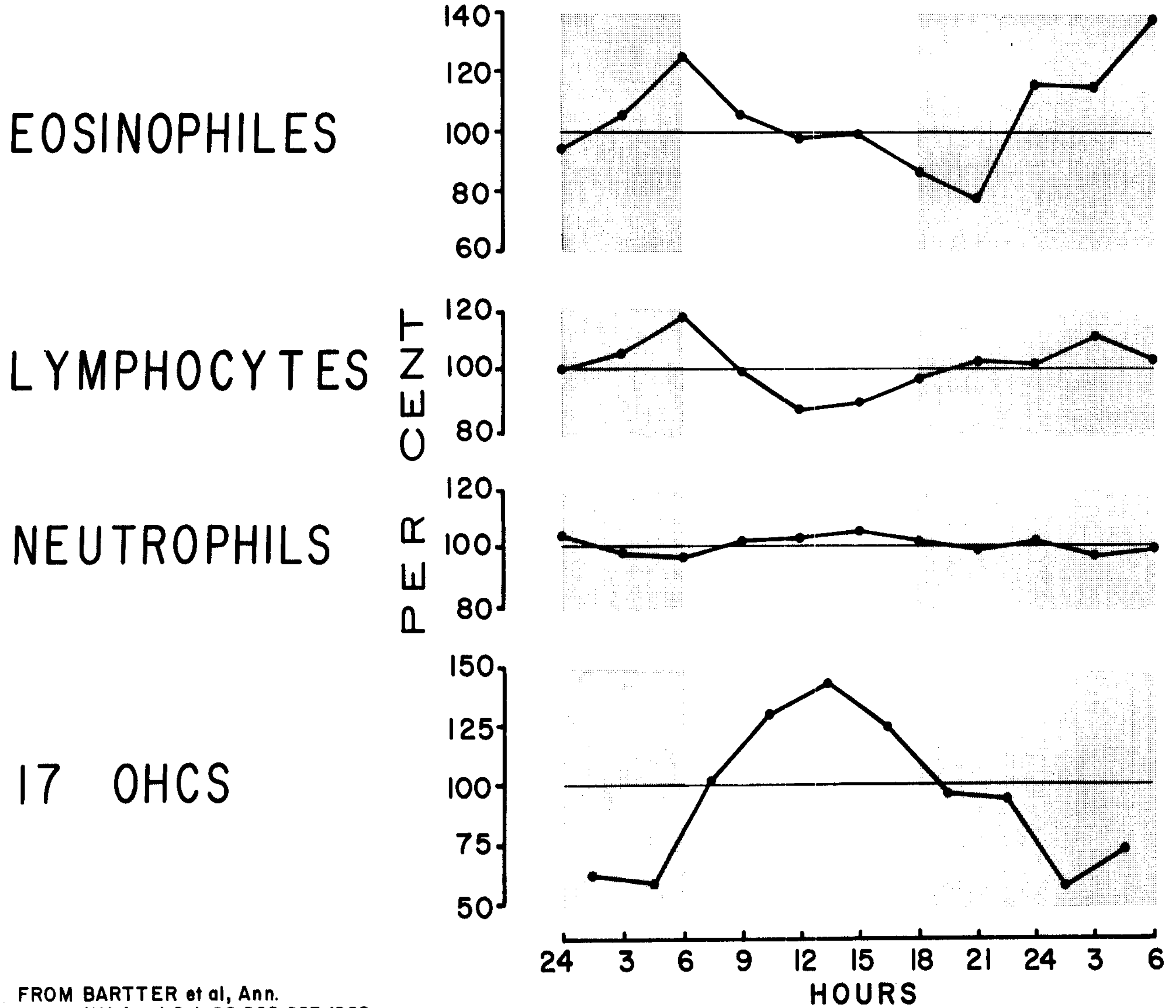
RESULTS AND DISCUSSION

In the interpretation of the results of an experiment such as this, it should be kept in mind that the measured values not only have a diurnal pattern of variation, but also that adrenal cortical secretion has a definite, homeostatic, regulatory function. Thus, it is well recognized that, under normal conditions in healthy individuals, the serum corticosteroid levels start to increase upon arising in the morning and are followed after a four or five hour period by slight neutrophilia and definite eosinopenia (10,19,21). Urinary 17-hydroxycorticosteroid concentration maxima occur at this time also, and the interrelated periodic nature of these changes has led Bartter et al.(1) to designate them as a circadian "map" as shown in Figure 1. Furthermore, it should be recalled that leukocytic and corticosteroid changes can be produced by exogenous ACTH (12,20) and this in turn has been interpreted as the mechanism of reaction to stressful situations transmitted through the hypothalmic-pituitary-adrenal axis (2,14).

Figure 2 shows the changes in leukocytic formed elements in the blood that occurred during the flights. Under the influence of zero gravity alone, both normal and L-D subjects had increases in total leukocyte and segmented neutrophil counts while lymphopenia and eosinopenia occurred at the same time. Although the changes in the mean values indicated on the bar graphs show the circadian trends that normally occur during the period from 8:00 a.m. to 12 noon, statistical analysis showed that only the normals had significant changes. If we may accept the latter as an indicator of stress, it would be of a low order.

When Coriolis acceleration was applied under zero gravity condition, the changes in the formed elements were also not significant for the L-D's but were highly significant in the normals, except for the lymphocytes. In this case the inference would be that Coriolis acceleration is a highly stressful situation in the environment of zero gravity for those with normal canal function.

RELATED DIURNAL BLOOD AND URINARY CHANGES



FROM BARTTER et al, Ann.
N.Y. Acad. Sci., 98:969-983, 1962

Figure 1

Figure 2

VARIATIONS IN LEUKOCYTIC ELEMENTS IN THE BLOOD AFTER ZERO-G, PARABOLIC FLIGHT

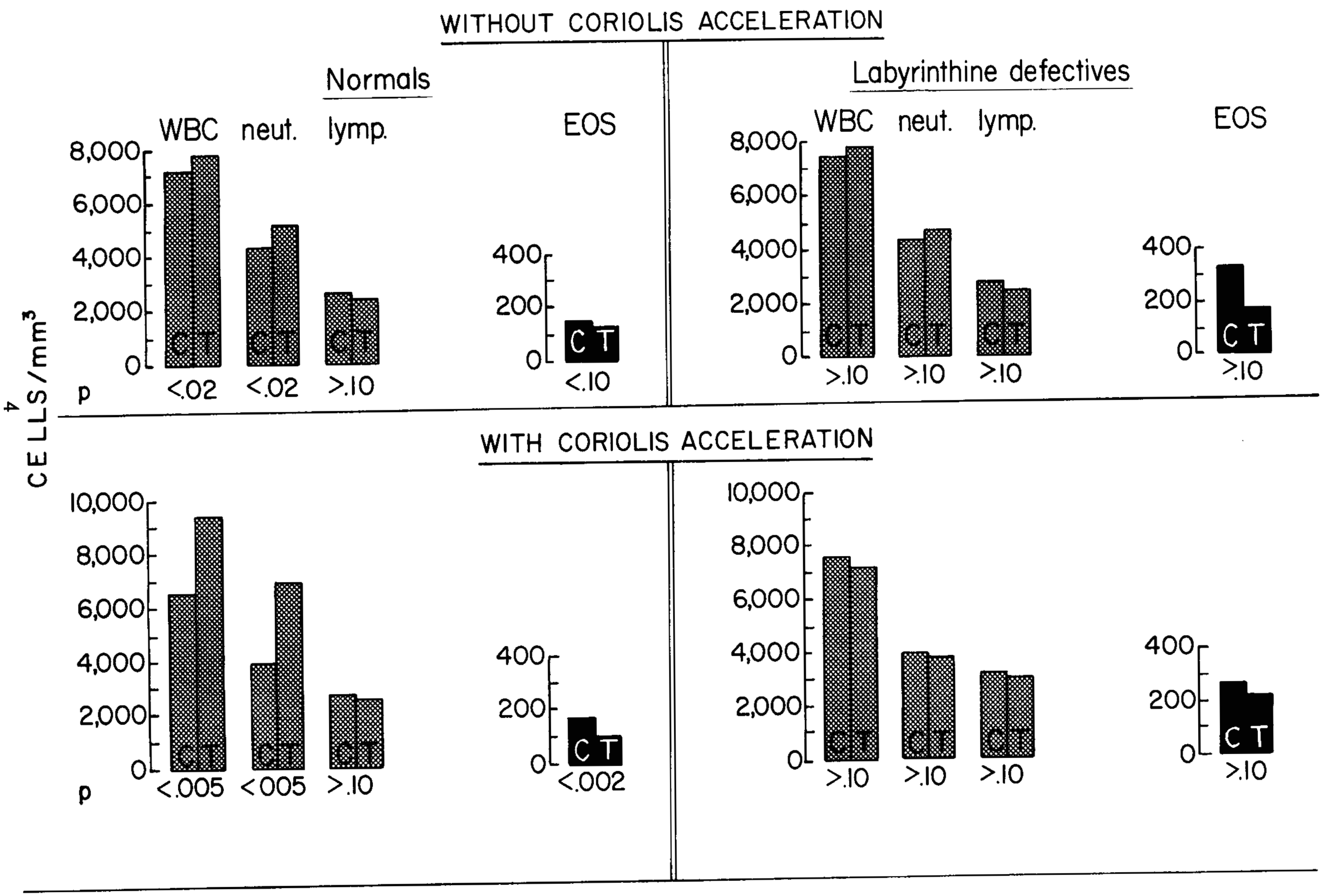


Figure 3 shows the unusual secretion pattern of corticoids from both subject groups under both types of stresses. Zero-G alone produced a lower, post-meridional excretion of adrenal cortical hormones in normal individuals after the flight than occurred at a similar time on a nonflight day. The reduction of a 50 per cent magnitude from normal is highly significant, and is indicative of adrenal hyperactivity four or five hours earlier. Such subnormal rates have been observed, first in the plasma, then in the urine in stress situations and are shown in the data of Hetzel et al.,(11), and others (5, 16). This explanation would be compatible with the significant changes in leukocytes in the normal subjects mentioned earlier, indicating a stressful situation early in the mission. In contrast, the L-D subjects under the same conditions did not have a significant increase in post-exposure excretion rates.

When both groups of subjects were exposed to zero gravity plus Coriolis acceleration, corticoid excretion patterns were quite similar to those found in zero-G alone. The normals had significant decreases in output and the L-D's had increases but at a low order of significance. Although there appears to be a clear-cut difference in excretion pattern between the two groups, which substantiates the hematological changes as far as stress is concerned, the reason for the increase in mean values of the L-D subjects is not clear at this time.

The measure of catechol amine excretion in both groups (Figure 3) was interesting in that changes paralleling corticoid excretion did not occur as they did in a previous experiment where greater than normal G forces and disorientation were experimental variables (3). Engle (7) has pointed out that, although adrenal cortical secretion increases after physical stress, the higher levels are not always concomitant with serum epinephrine increases. Conversely, an increase in serum epinephrine level is not always accompanied by elevated corticoid levels (2). Furthermore, Elmadjian et al.(6) demonstrated that catechol increments occur with emotional displays, and Mason (16) felt that corticoid increases are related more to distress or distress involvement. The results of this experiment would be in accord with those views. While there were no observations which would indicate that the subjects were occupied with the emotion of fear, distress was evidenced by the fact that the majority of the normals, but none of the L-D's, were nauseated by the Coriolis acceleration (9).

The mean pyruvic and lactic acid concentrations were depressed (Figure 4) in seven out of eight postflight samples, but the deviations were not significant at the 90 per cent confidence level. Lactic dehydrogenase changes also were not significant. Although there may be an indication in the data that muscle metabolism parameters are affected by Coriolis acceleration in the zero gravity state, the length of exposure was perhaps too short to produce pronounced changes.

Table I summarizes the confidence levels of the determined values of the experiment. If levels of 0.1 and lower are assumed as significant, it would appear that the normal subjects had leukocytic and corticosteroid changes indicative of stress situations especially when subjected to Coriolis acceleration in the zero gravity state. Labyrinthine defective subjects were not similarly affected by the conditions of the experiment.

Figure 3

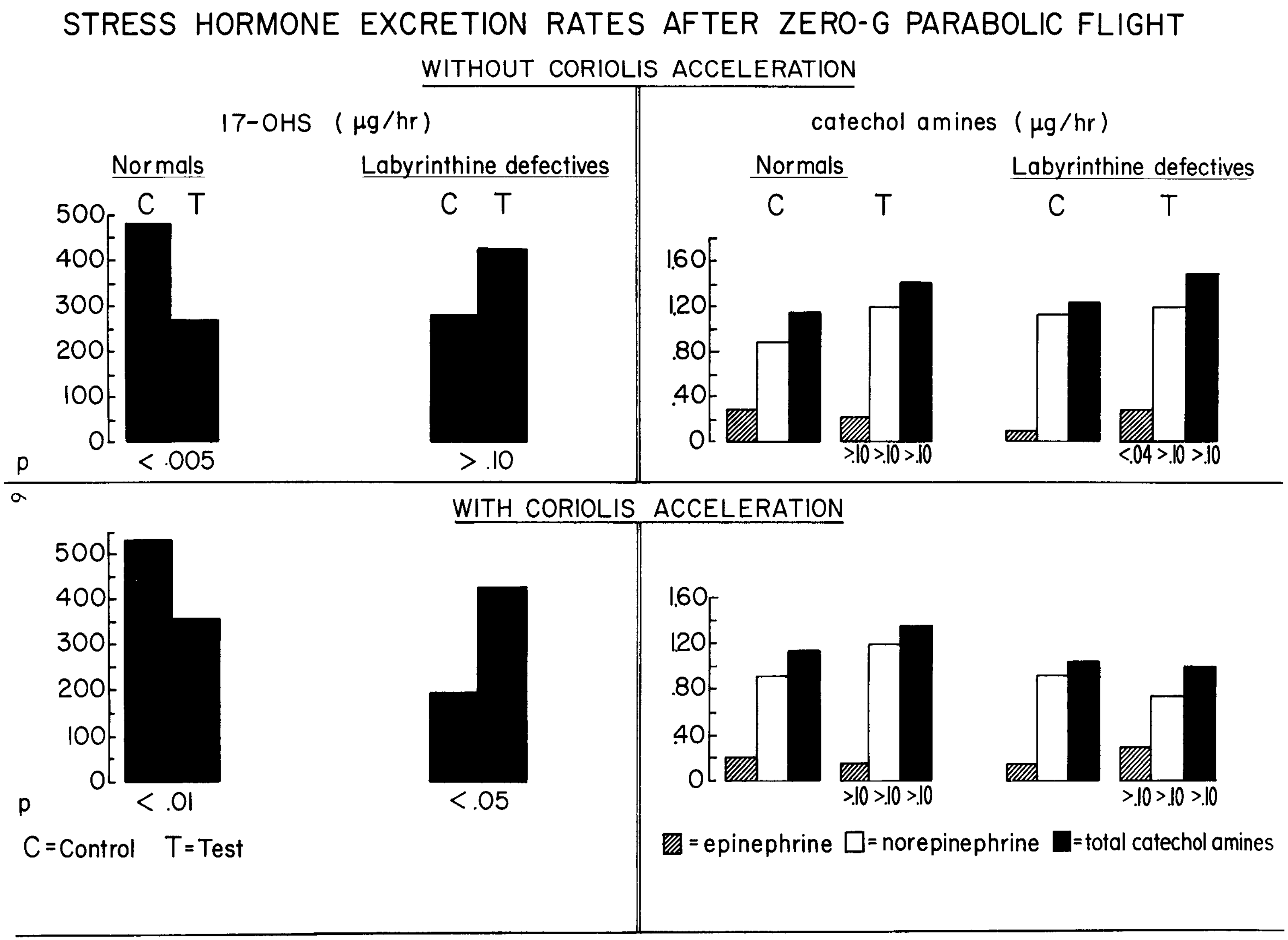

STRESS HORMONE EXCRETION RATES AFTER ZERO-G PARABOLIC FLIGHT
WITHOUT CORIOLIS ACCELERATION
17-OHS (μg/hr)
Normals
Labyrinthine defectives
C T
C T
500
400
300
200
100
0
p
< .005
> .10
catechol amines (μg/hr)
Normals
Labyrinthine defectives
C T
C T
1.60
1.20
.80
.40
0
>.10 >.10 >.10
<.04 >.10 >.10
WITH CORIOLIS ACCELERATION
< .01
< .05
>.10 >.10 >.10
>.10 >.10 >.10
C=Control T=Test
=epinephrine
=norepinephrine
=total catechol amines

Figure 4

CHANGES IN BIOCHEMICAL VALUES ASSOCIATED WITH MUSCLE METABOLISM AFTER SHORT-TERM ZERO-GRAVITY FLIGHT

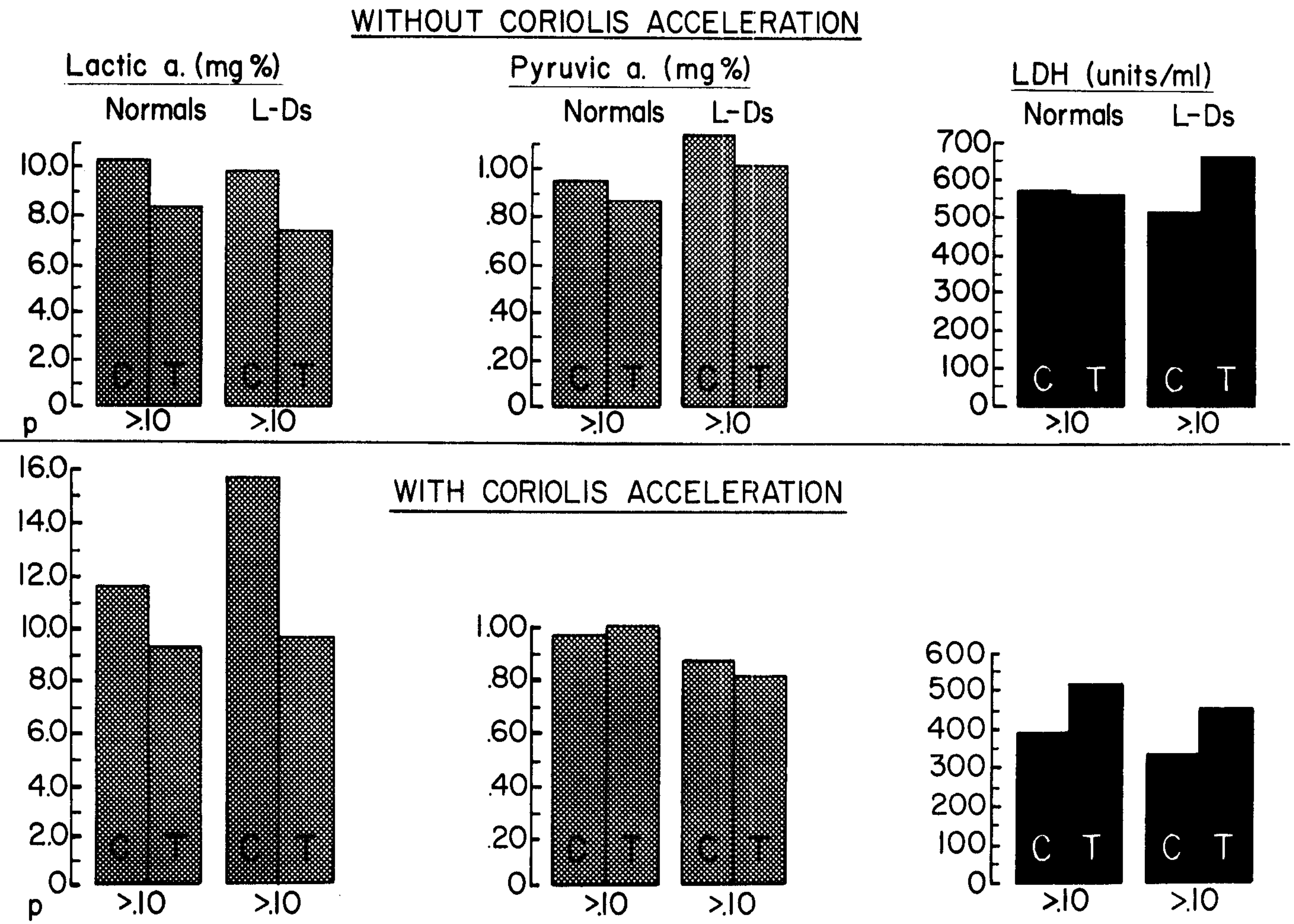


Table I

Summary of Confidence Levels of Blood and Urinary Changes After Repetitive Zero-G Flight
Mann-Whitney *p* Values

		Blood Values							Urine Values			
		WBC	Neut.	Lymp.	Eos.	Lac a.	Pyruv. a.	LDH	17-OHS	E	NE	E + NE
Normals	Zero G	$<.02$	$<.02$	NS	$<.10$	NS	NS	NS	$<.005$	NS	NS	NS
	Zero G + Cor. Accel.	$<.005$	$<.005$	NS	$<.002$	NS	NS	NS	$<.10$	NS	NS	NS
Lab.-Def.	Zero G	NS	NS	NS	NS	NS	NS	NS	NS	$<.04$	NS	NS
	Zero G + Cor. Accel.	NS	NS	NS	NS	NS	NS	NS	$<.05$	NS	NS	NS

Confidence levels of greater than .10 considered not significant.

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